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Advanced Stellar Compass

Juno

Software Interface Specification - Addendum 1

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1 Scope

The scope of this Software Interface Specification Addendum is to provide information specifically related to the Juno/ASC radiation data acquired during the Juno Extended Mission #1 and onwards, starting August 1, 2021.

Apart from describing calibration and data format the addendum lists a per orbit assessment of the dataset integrity.

This addendum describes the calibration activities of data from orbit 36-67.

2 Documents

Reference documents

RD1. Connerney, J. E. P., Benn, M., Bjarnø, J. B., Denver, T., Espley, J., Jørgensen, J. L., Jørgensen, P. S., Lawton, P., Malinnikova Bang, A., Merayo, J. M. G., Murphy, S., Odom, J., Oliversen, R., Schnurr, R., Sheppard, D., & Smith, E. J. (2017). The Juno Magnetic Field Investigation. *Space Science Reviews*, *213*(1-4), 39–138. https://doi.org/10.1007/s11214-017-0334-z

RD2. Denver, T., Sushkova, J., Jørgensen, J.L., Ghizoni, L., Herceg, M., Toldbo, C., Benn, M, Jørgensen, P.S., Fléron, R., Connerney, J.E.P, Becker, H.N., Bolton, S.J. (2024). The Juno ASC as an Energetic Particle Counter. *Space Sci Rev 220*(86). https://doi.org/10.1007/s11214-024-01120-y

RD3. Denver, T., Benn, M (2024). JN-DTU-SP-3001 Juno Advanced Stellar Compass Software Interface Specification. Avaliable on the PDS: Planetary Plasma Interactions node

3 Introduction

Please refer to RD3 for an overview of the Juno mission.

Around Juno's transition from prime mission to extended mission (August 1, 2021), the camera head units (CHUs) of the Advenced Stellar Compass (ASC) star tracker reached the design lifetime and within a short period all lost light sensitivity. More specifically, two different effects occur. The integrated electrons in the integration layer can no longer be transferred to the readout layer. The charge transfer efficiency (CTE) in the readout layer is decreased.

While the Post Light Sensitivity Seace (PLSS) CHUs are no longer able to perform their primary function, star tracking, the readout process of the CCDs, even at lowered CTE, is still sensitive to radiation impacts in the readout layer, but with a much-decreased sensitivity relative to nominal.

In summary, following cease of light sensitivity the (now PLSS) CHUs can no longer observe focal objects in the form of photons collimated by the optics, but is usable for radiation monitoring with the following characteristics:

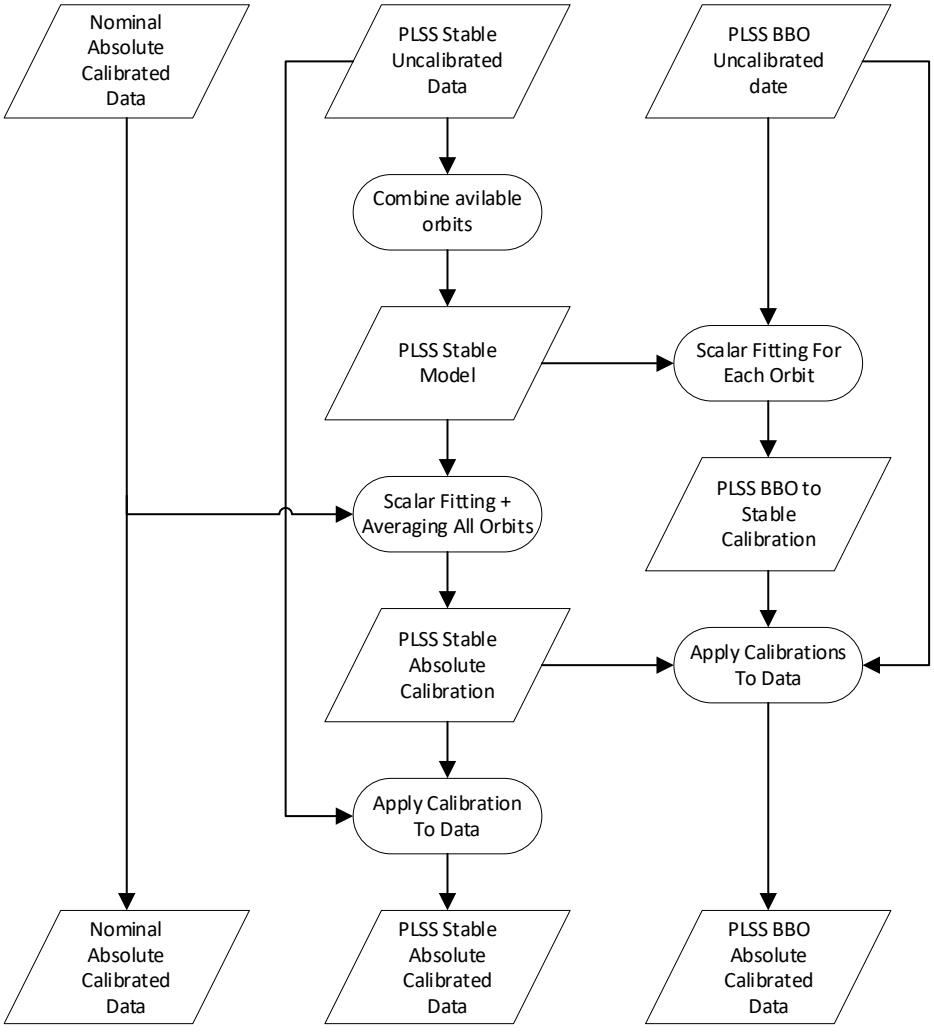
- Decreased sensitivity
- Linear response, even at high radiation fluxes
- Potential long term sensitivity variation

4 Calibration

The PLSS data has the basic characteristics of being linear with the external flux and lower sensivity relative to the nominal data. There are basically two classes of PLSS data:

- PLSS-U: Unstable data (orbit 37-42), which immediately follows the end design life. In this period the sensitivity varies abruptly between discrete steps in an undeterministic fassion.
- PLSS-B: BBO but stable data (orbit 43-51), slightly more stable conditions are met but largely impacted by photons from bright image objects (Jovian moons) traversing the cover of the CCD readout layer generating electrons directly in the CCD readout layer.
- PLSS-S. Stable data (orbit 52 and onwards), which start dozens of orbit after the end of design life. During these orbits the sensitivity appears relatively stable but still much lower than during nominal conditions.

In order to achieve an absolute calibration the following approach is applied:



1: A model of the electron flux in the Jovian proximity is generated from the post-light-sensivity-cease data. Only data the express stable conditions is included.

2: Data from all orbits (nominal AND post light sensitivity data) for orbits not included in the model generation is fitted to the model for matching locations in the Jovian magnetospheric environment. Since both model and data scales linearly with the electron flux, the fit is described with a factor only.

3a: For nominal orbit radition data, which have already been absolutely calibrated to omniflux, this factor can be directly used as absolute calibration of the orbits data that was included in the model generation. Since each nominal orbit contributes with one such factor, a common factor is found by simple averaging. Applying this factor to the PLSS Stable data, PLSS Stable Absolute Calibrated data is obtained

3b: For post light sensitivity cease orbits NOT included in the model generations, i.e. because they are detoriated by BBO presence and long term sensitivity variation, the factor is a per-orbit calibration. Each of these factors calibrates an orbit of PLSS BBO data to PLSS Stable sensitivity level. Applying the factor derived in 3a, further brings the PLSS BBO data to Nominal Calibrated Sensitivity

3c: For PLSS orbits with many discontinuities, calibration is meaningless. No calibration is applied to these data set.

Using the above process all PLSS data from orbit 43-67 is calibrated to nominal absolute sentivity. Data from orbit 37-42 all exhibit large discontinuities and calibration to absolute omniflux is not achievable. For these set, the calibrated data are all marked with “0” in the archieved products.

5 Data Format

The data format and label file format follows the description provided in RD3.

6 Summary of Orbits

The table belows provide a high level summary of the radiation omniflux measured by ASC on all Juno extended mission orbits (to time of release of this addendum):

Orbit	Available CHUs	Category	Observations	Absolute calibration
36	C	Nominal		Yes
37	C	PLSS-U	Many big discontinuities	No
38	B, C, D	PLSS-U	Many big discontinuities	No
39	D	PLSS-U	Many big discontinuities	No
40	D	PLSS-U	Many big discontinuities	No
41	B, C, D	PLSS-U	Many big discontinuities	No
42	B, C, D	PLSS-U	Many big discontinuities	No
43	B, C, D	PLSS-B	Many BBO flagged objects	Yes
44	B, C, D	PLSS-B	Many BBO. Discontinuity in outer leg	Yes
45	B, C, D	PLSS-B	Many BBO. Discontinuity in outer leg	Yes
46	B, C, D	PLSS-B	Many BBO flagged objects	Yes
47	B, C, D	PLSS-B	Many BBO flagged objects	Yes
48	B, C, D	PLSS-B	Many BBO flagged objects	Yes

49	B, C, D	PLSS-B	Many BBO flagged objects	Yes
50	B, C, D	PLSS-B	Many BBO flagged objects	Yes
51	B, C, D	PLSS-B	Many BBO flagged objects	Yes
52	B, C, D	PLSS-S		Yes
53	B, C, D	PLSS-S		Yes
54	B, C, D	PLSS-S		Yes
55	B, C, D	PLSS-S		Yes
56	B, C, D	PLSS-S		Yes
57	B, C, D	PLSS-S		Yes
58	B, C, D	PLSS-S		Yes
59	B, C, D	PLSS-S		Yes
60	B, C, D	PLSS-S		Yes
61	B, C, D	PLSS-S		Yes
62	B, C, D	PLSS-S		Yes
63	B, C, D	PLSS-S		Yes
64	B, C, D	PLSS-S	Only data up to 2024-08-18T07:35:57	Yes
65	B, C	PLSS-S		Yes
66	B, C	PLSS-S		Yes
67	B, C	PLSS-S		Yes

7 Summary

All radiation data (from orbit 36-67) from the Juno ASC instrument acquired during Juno extended mission #2 have been archieved to the PDS PPI node.

For all data where possible to obtain an absolute calibration, such calibration has been performed and the calibrated omniflux estimates are part of the archived products.

Note that the calibration process includes high uncertainties. Due to the complex calibration process it is not possible to provide error bars. Hence, the ASC radiation data products pertaining to the Juno extended mission #1 shall be used with extreme caution.